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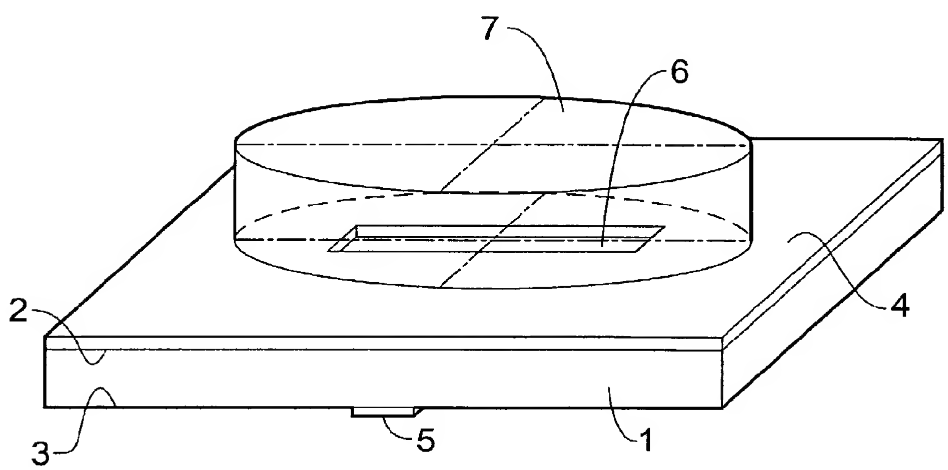
(54) **Title:** DUAL BAND SLOT FED DIELECTRIC RESONATOR ANTENNA



(57) **Abstract:** An antenna system comprising a dielectric substrate (1) of dielectric constant k_1 having first (2) and second (3) sides, with a grounded plate (4) on the first side (2) and a strip feed (5) on the second side (3) for transferring energy to and from the antenna system. A slot (6) provided in the grounded plate (4) is used as a dielectrically loaded antenna having a resonant frequency determined by the size and shape of the slot (6). A dielectric resonator (7, 8, 12) of dielectric constant k_2 disposed on the grounded plate (4) on a side remote from the dielectric substrate (1) and covering the slot (6) is used as a dielectric resonator antenna having a resonant frequency determined by a size and shape of the dielectric resonator (7, 8, 12). The antenna system thus acts as a compound antenna in two frequency bands with only a single feed (5). There may further be provided a conductive wall in electrical contact with the grounded plate and placed on an electric field symmetry plan of the dielectric resonator antenna,thus achieving reduced back lobes.

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DUAL BAND SLOT FED DIELECTRIC RESONATOR ANTENNA

The present invention relates to a dielectric resonator antenna which combines two different radiation mechanisms simultaneously excited by a single feed mechanism so as to transmit and receive signals in two distinct frequency bands.

Since the first systematic study of DRAs in 1983 [LONG, S.A., McALLISTER, M.W., and SHEN, L.C.: "The Resonant Cylindrical Dielectric Cavity Antenna", IEEE Transactions on Antennas and Propagation, AP-31, 1983, pp 406-412], interest has grown in their radiation patterns because of their high radiation efficiency, good match to most commonly used transmission lines and small physical size [MONGIA, R.K. and BHARTIA, P.: "Dielectric Resonator Antennas - A Review and General Design Relations for Resonant Frequency and Bandwidth", International Journal of Microwave and Millimetre-Wave Computer-Aided Engineering, 1994, **4**, (3), pp 230-247]. Most of the configurations reported have used a slab of dielectric material mounted on a ground plane excited by either an aperture feed in the ground plane or by a probe inserted into the dielectric material.

In general, a DRA consists of a volume of a dielectric material disposed on a grounded substrate, with energy being transferred to and from the dielectric material by way of monopole probes inserted into the dielectric material or by way of monopole aperture feeds provided in the grounded substrate (an aperture feed is a discontinuity, generally rectangular in shape, although oval, oblong, trapezoidal or butterfly/bow tie shapes and combinations of these shapes may also be appropriate, provided in the grounded substrate where this is covered by the dielectric material. The aperture feed may be excited by a strip feed in the form of a microstrip transmission line, coplanar waveguide, slotline or the like which is located on a side of the grounded substrate remote from the dielectric material). Alternatively, dipole probes may be inserted into the dielectric material, in which case a grounded substrate is not required. By providing multiple feeds and exciting these sequentially

or in various combinations, a continuously or incrementally steerable beam or beams may be formed.

The resonant characteristics of a DRA depend upon the shape and size of the volume of dielectric material and also on the shape, size and position of the feeds thereto. It is to be appreciated that in a DRA, it is the dielectric material that resonates when excited by the feed. This is to be contrasted with a dielectrically loaded antenna, in which a traditional conductive radiating element is encased in a dielectric material which modifies the resonance characteristics of the radiating element.

DRAs are a relatively new invention dating essentially from 1983 [LONG, S.A., McALLISTER, M.W., and SHEN, L.C.: "The Resonant Cylindrical Dielectric Cavity Antenna", IEEE Transactions on Antennas and Propagation, AP-31, 1983, pp 406-412]. This reference describes a DRA as being “a novel structure which seemingly has the possibility of radiating efficiently”. Describing this new antenna as a resonant cylindrical dielectric cavity without metallic walls, the paper notes that “little or no work has been devoted to this structure as a radiator, nor has a complete investigation of the external fields been made.”

In contrast, dielectrically loaded antennas have a long history. One of the best known antenna reference books [“The Handbook of Antenna Design”, Ed Rudge, Milne, Olver & Knight, pub. Peter Peregrinus for the IEE, page 840] explains in a section entitled “Dielectrically-loaded antennas” that “two different aspects of dielectric loading are considered here. The first deals with attempts to reduce the physical size of antennas by loading and the second with the use of dielectric materials as protection, where the aim is to minimise the influences of the dielectric.” Furthermore, the book points out that “The search for a loading material which would permit a dramatic reduction in the size of antennas has continued since antennas were first used.”

Dielectric loading of conventional antenna elements such as monopoles, dipoles, patches and slots is thus a very old technology where the dielectric has an impact on the size and performance of the antenna element. In contrast, DRAs are a much newer technology and it is the dielectric material itself that is the radiating element - the dielectric does not necessarily have to have an antenna element imbedded within it (if it is slot fed, for example).

It is known from FAN, Z. and ANTAR, Y.M.M.: "Slot-Coupled DR Antenna for Dual-Frequency Operation", IEEE Transactions on Antennas and Propagation, vol 45, 1997, pp. 306-308 to provide a dual-band DRA comprising two rectangular dielectric resonators displaced near two edges of a single slot in the ground plane of a microstrip line. The teaching in this document is that a dual band antenna is easily and usually achieved by using two separate resonators with the same feeding mechanism.

According to a first aspect of the present invention, there is provided an antenna system comprising a dielectric substrate of dielectric constant k_1 having first and second sides, with a grounded plate on the first side of the dielectric substrate and a strip feed on the second side of the dielectric substrate for transferring energy to and from the antenna system, a slot in the grounded plate which is activatable as a dielectrically loaded antenna having a resonant frequency determined by a size and shape of the slot and by characteristics of any material filling the slot, and a dielectric resonator of dielectric constant k_2 disposed on the grounded plate on a side remote from the dielectric substrate and covering the slot, the dielectric resonator being activatable as a dielectric resonator antenna having a resonant frequency determined by a size, shape and material of the dielectric resonator, wherein there is further provided a conductive wall in electrical contact with the grounded plate and abutting or in close proximity to a surface of the dielectric resonator, and wherein the conductive wall is contacted by the slot.

According to a second aspect of the present invention, there is provided an antenna system comprising a dielectric substrate of dielectric constant k_1 having first and second sides, with a grounded plate on the first side of the dielectric substrate and a strip feed on the second side of the dielectric substrate for transferring energy to and from the antenna system, a slot in the grounded plate which is activatable as a dielectrically loaded antenna having a resonant frequency determined by a size and shape of the slot and by characteristics of any material filling the slot, and a dielectric resonator of dielectric constant k_2 disposed on the grounded plate on a side remote from the dielectric substrate and covering the slot, the dielectric resonator being activatable as a dielectric resonator antenna having a resonant frequency determined by a size, shape and material of the dielectric resonator.

According to a third aspect of the present invention, there is provided mobile telecommunications device incorporating an antenna system of the first or second aspects of the present invention.

Preferably, the slot and the dielectric resonator are configured so as to resonate at different frequencies. By changing the size and/or shape of either one or both of the slot and the dielectric resonator, the resonant frequencies may be tuned substantially independently of each other. The resonant frequencies may also be tuned by selecting appropriate materials for the dielectric resonator and for any dielectric material filling the slot.

The slot may advantageously be provided or filled with a dielectric material of dielectric constant k_3, which may be the same material as that of the dielectric substrate (in which case $k_3 = k_1$), as that of the dielectric resonator (in which case $k_3 = k_2$), or a different material, provided that $k_3 \leq k_2$.

Embodiments of the present invention seek to provide an antenna system able to transmit and receive beams in two distinct frequency bands by combining two different radiation mechanisms simultaneously excited by a single feeding

mechanism. The dielectrically loaded antenna formed by the slot in the grounded plane and any dielectric material filling the slot is tuned to a first resonant frequency by modifying its shape and geometrical dimensions, and optionally by filling the slot with a dielectric material of dielectric constant k_3. The dielectric resonator antenna formed by the dielectric resonator and the grounded plate is tuned to a second resonant frequency, different from the first, by choosing the shape and geometrical dimensions of the dielectric resonator appropriately.

Each of the dielectric resonator, dielectric substrate and dielectric material may be made out of any appropriate dielectric substance or combination of dielectric substances, including fluids such as water or air, or any other appropriate dielectric liquid, gas or gel, or a dielectric solid including plastics or ceramic materials.

With particular reference to the dielectric material provided in or filling the slot, this may be a dielectric fluid such as water or air, or any other suitable dielectric liquid or gas, held in the slot by the dielectric substrate on one side of the grounded plate and by the dielectric resonator on the other. Alternatively, where the slot does not extend all the way through the grounded plate but is configured as a trench or the like formed therein, the dielectric material may be held in the trench by the dielectric resonator. Alternatively, the dielectric material may be formed as a dielectric solid including plastics or ceramic materials, or as a dielectric gel. In a particularly preferred embodiment, the dielectric material is formed as an adhesive, optionally a gel adhesive, which may be used to bind the dielectric resonator to the dielectric substrate through the slot in the grounded plate.

With particular reference to the dielectric resonator, this may be formed of any suitable dielectric substance, or a combination of different dielectric substances, having an overall positive dielectric constant k_2. In preferred embodiments, k_2 is at least 10, and may be at least 50 or even at least 100. k_2 may be larger, for example at least 1000, although available dielectric substances tend to limit such use to low frequencies. The dielectric resonator may include dielectric substances in liquid,

solid or gaseous states or any intermediate state. The dielectric resonator may be formed as first dielectric substance embedded in a second dielectric substance, the first substance having a dielectric constant lower than that of the second substance.

Advantageously, with regard to the second aspect of the present invention, there may further be provided a conductive wall in contact with or in close proximity to a preferably generally planar surface of the dielectric resonator and in electrical contact with the grounded plate. With regard to the first and second aspects of the present invention, the conductive wall may intersect the grounded plate along a line and is preferably disposed such that it simultaneously coincides with a geometrical symmetry plane of the slot and an electric field symmetry plane of the dielectric resonator. The conductive wall may be provided with a dielectric substrate on a side remote from the dielectric resonator, and may be disposed generally perpendicularly to the grounded plane.

In some embodiments, two conductive walls may be provided, arranged at an angle to each other. The angle may be substantially 90°, 60°, 45°, 30° or 180° or any angle between 0° and 180°. A corresponding 'L' or 'V' shaped slot is then provided in the grounded plate or plane so as to receive or correspond to lower edges of the walls. The two conductive walls are in electrical contact with each other where they intersect, and the line of intersection may be generally perpendicular to the grounded plate or plane, as may the walls themselves.

Provision of a conductive wall positioned as described above has the advantage of reducing radiation backlobes on the side of the conductive wall remote from the dielectric resonator. Low backlobes are of particular importance in the application of the present invention as an antenna for mobile telephones, since it is desirable to reduce radiation emissions in directions which pass through a user's head, for example.

In one embodiment of the antenna system of the present invention, the dielectric resonator is provided as a semicylindrical slab of dielectric substance having a generally rectangular planar base and two opposed generally semicircular planar sides. The dielectric resonator is positioned with one of the semicircular sides against a grounded plate and with the rectangular base against a conductive wall which is in contact with and intersects the grounded plate along a line. A dielectric substrate is provided on a side of the grounded plate remote from the dielectric resonator. A further dielectric substrate may also be provided behind the conductive wall so as to assist in adjusting the impedance of the antenna system. The dielectric resonator may be resonated in its fundamental $HEM_{11\delta}$ mode by a strip feed on a side of the dielectric substrate remote from the grounded plate and by an aperture feed in the form of a slot provided in the grounded plate and covered by the dielectric resonator. Other resonant modes may be used with other geometries. The dielectric resonator may be dimensioned so as to resonate at 1800MHz and tuned by adapting a length of the strip feed appropriately. Independently, the slot in the grounded plate is filled with a dielectric water-based gel and the dimensions of the slot are selected or tuned so as to cause it to resonate at 900MHz. When the dielectric resonator is placed so as to cover the slot, the antenna system as a whole will present two resonant frequencies, one at 1800MHz and one at 900MHz.

The embodiment described above has a characteristic radiation pattern in the form of a figure of eight with a backlobe (on the side of the conductive wall remote from the dielectric resonator) considerably smaller than a front lobe (on the side of the conductive wall where the dielectric resonator is positioned). For some applications where the antenna system is located close to particular objects (such as the head of a user of a mobile telephone fitted with the antenna system), this arrangement can provide a very low backlobe, thereby reducing radiation emissions in the direction of the backlobe and hence improving safety.

The strip feed may be in the form of a microstrip transmission line printed on a side of the dielectric substrate remote from the grounded plate, or possibly in the form of a coplanar waveguide, slotline or coplanar strips.

Instead of using a semicylindrical dielectric resonator, a semiconical dielectric resonator having a generally triangular planar base and one generally semicircular planar side may be used, with the conductive wall placed against the triangular planar base. Alternatively, a truncated semiconical dielectric resonator having a generally triangular planar base and two generally semicircular planar sides, one larger than the other, may be used.

Alternatively, the dielectric resonator may have a cross-section in the general form of a trapezoid or trapezium, preferably a regular trapezoid or trapezium such as described, for example, by a regular semihexagon. This form of dielectric resonator has a generally rectangular planar base and two planar sides of generally trapezoidal shape.

In the above embodiments, it is to be appreciated that the dielectric resonator generally has a cross-section which corresponds to half of a regular polygon or circle, with the conductive wall positioned along the planar base of the dielectric resonator so as to contain a longitudinal symmetry axis of a notional shape having a cross-section corresponding to a full regular polygon or circle.

Other appropriate shapes having cross-sections other than semicircular or trapezoidal may be chosen for the dielectric resonator.

For mobile telephone or other communications device (including personal computers, personal digital assistants and the like) applications, the dielectric substrate may be part of a printed circuit board within the telephone or communications device, or may be a part of a casing thereof.

For a better understanding of the present invention and to show how it may be carried into effect, reference shall now be made by way of example to the accompanying drawings, in which:

FIGURE 1 shows a perspective view of an antenna of a first embodiment of the present invention;

FIGURE 2 shows a vertical cross-section through the antenna of Figure 1;

FIGURE 3 shows a plan view of the antenna of Figure 1;

FIGURE 4 shows a perspective view of an antenna of a second embodiment of the present invention;

FIGURE 5 shows a vertical cross-section through the antenna of Figure 4;

FIGURE 6 shows a plan view of the antenna of Figure 4;

FIGURE 7 shows a plan view of an antenna of a third embodiment of the present invention;

FIGURE 8 shows a side elevation of the antenna of Figure 7; and

FIGURE 9 shows a radiation pattern measured in azimuth for the antenna of Figures 7 and 8.

Figures 1, 2 and 3 show an antenna system comprising a dielectric substrate 1 (which may be made of a material such as fibreglass or PTFE, among others) of dielectric constant k_1 having first 2 and second 3 sides. A grounded conductive plate 4 is mounted on the first side 2 of the dielectric substrate, and a microstrip feed line 5 is printed on the second side 3 thereof for transferring energy to and from the antenna

system. The grounded plate 4 has a rectangular slot 6 which includes a dielectric material of dielectric constant k_3, and which is activatable as a dielectrically loaded antenna having a resonant frequency determined by the size and shape of the slot 6. The slot 6 and the microstrip feed line 5 are arranged so as to be generally perpendicular to each other in longitudinal orientation. A cylindrical dielectric resonator 7 (which may be made of materials such as plastics with high relative permittivities, ceramics, water-based gels, among others) of dielectric constant k_2 is disposed over the slot 6 on the grounded plate 4, the dielectric resonator 7 being activatable as a dielectric resonator antenna having a resonant frequency determined by the size and shape thereof.

The dielectrically loaded antenna formed by slot 6 and the dielectric resonator antenna formed by resonator 7 are tuned to different resonant frequencies and caused to resonate at these frequencies by way of energy transfer from the single microstrip feed line 5. In this way, a dual band antenna system operating simultaneously at the two resonant frequencies is obtained.

A preferred embodiment of the present invention is shown in Figures 4, 5 and 6, which show an antenna system comprising a dielectric substrate 1 of dielectric constant k_1 having first 2 and second 3 sides. A grounded conductive plate 4 is mounted on the first side 2 of the dielectric substrate, and a microstrip feed line 5 is printed on the second side 3 thereof for transferring energy to and from the antenna system. The grounded plate 4 has a rectangular slot 6 which includes a dielectric material of dielectric constant k_3, and which is activatable as a dielectrically loaded antenna having a resonant frequency determined by the size and shape of the slot 6. The slot 6 and the microstrip feed line 5 are arranged so as to be generally perpendicular to each other in longitudinal orientation. A semicylindrical dielectric resonator 8 of dielectric constant k_2, having a rectangular planar base 9 and two opposed semicircular planar sides 10, is disposed on the grounded plate 4, such that the slot 6 is covered by one of the sides 10 and aligned along an edge of the base 9. The base 9 abuts a conductive wall 11 which is generally perpendicular to the

grounded plate 4 and in conductive contact therewith along a straight line of intersection which corresponds to the alignment between the edge of the base 9 and the slot 6. It will be appreciated that this embodiment is in effect just one half of the embodiment of Figures 1, 2 and 3, the conductive wall 11 forming a mirror plane which bisects the dielectric resonator 7, the dielectric substrate 1 and the grounded plate 4 along a longitudinal symmetry line of the slot 6 of that embodiment.
The presence of the conductive wall 11 provides for a significant reduction in the radiation backlobe generated by the antenna system on the side of the conductive wall 11 remote from the dielectric resonator 8, which is useful in applications such as mobile telephones where it is desirable to reduce radiation emissions in the direction of a user's head, for example.

An embodiment of the present invention which is particularly suited for use with a mobile telephone is shown in Figures 7 and 8. This embodiment has much the same configuration as that of Figures 4, 5 and 6, with all parts being labelled accordingly, except in that the dielectric resonator 12 is semihexagonal rather than semicylindrical in shape. Further differences are that the conductive wall 11 is mounted on a dielectric printed circuit board 13 of a mobile telephone (not shown) and that the microstrip feed line 5 passes up the circuit board 13 before passing under and contacting the dielectric substrate 1, which is connected perpendicularly to the circuit board 13.

Figure 9 shows a radiation pattern for the antenna of Figures 7 and 8 measured in azimuth. It can clearly be seen that the patterns for both frequencies (950MHz and 1830MHz) are well matched in the larger frontlobes 14, 15; and also that the backlobes 16, 17 are of a significantly reduced size in comparison to the frontlobes 14, 15. This is particularly advantageous for mobile telephone applications where the backlobes 16, 17 are directed towards a user's head and cause significantly less irradiation thereof that the frontlobes 14, 15.

The preferred features of the invention are applicable to all aspects of the invention and may be used in any possible combination.

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", mean "including but not limited to", and are not intended to (and do not) exclude other components, integers, moieties, additives or steps.

CLAIMS:

1. An antenna system comprising a dielectric substrate of dielectric constant k_1 having first and second sides, with a grounded plate on the first side of the dielectric substrate and a strip feed on the second side of the dielectric substrate for transferring energy to and from the antenna system, a slot in the grounded plate which is activatable as a dielectrically loaded antenna having a resonant frequency determined by a size and shape of the slot and by characteristics of any material filling the slot, and a dielectric resonator of dielectric constant k_2 disposed on the grounded plate on a side remote from the dielectric substrate and covering the slot, the dielectric resonator being activatable as a dielectric resonator antenna having a resonant frequency determined by a size, shape and material of the dielectric resonator, wherein there is further provided a conductive wall in electrical contact with the grounded plate and abutting or in close proximity to a surface of the dielectric resonator, and wherein the conductive wall is contacted by the slot.

2. An antenna system comprising a dielectric substrate of dielectric constant k_1 having first and second sides, with a grounded plate on the first side of the dielectric substrate and a strip feed on the second side of the dielectric substrate for transferring energy to and from the antenna system, a slot in the grounded plate which is activatable as a dielectrically loaded antenna having a resonant frequency determined by a size and shape of the slot and by characteristics of any material filling the slot, and a dielectric resonator of dielectric constant k_2 disposed on the grounded plate on a side remote from the dielectric substrate and covering the slot, the dielectric resonator being activatable as a dielectric resonator antenna having a resonant frequency determined by a size, shape and material of the dielectric resonator.

3. An antenna system as claimed in claim 1 or 2, wherein the slot and the dielectric resonator are configured to resonate at different frequencies.

4. An antenna system as claimed in claim 1, 2 or 3, wherein the slot is provided or filled with a dielectric material of dielectric constant k_3.

5. An antenna system as claimed in claim 2 or any claim depending therefrom, wherein there is further provided a conductive wall in electrical contact with the grounded plate and abutting or in close proximity to a surface of the dielectric resonator, and wherein the conductive wall is contacted by the slot.

6. An antenna system as claimed in claim 1 or 5, wherein the conductive wall intersects the grounded plate along a line and is disposed such that it simultaneously coincides with a geometrical symmetry plane of the slot and an electric field symmetry plane of the dielectric resonator.

7. An antenna system as claimed in claim 1, 5 or 6, wherein the conductive wall is provided with a dielectric substrate on a side remote from the dielectric resonator.

8. An antenna system as claimed in claim 1, 5, 6 or 7, wherein the conductive wall is substantially perpendicular to the grounded plate.

9. An antenna system as claimed in claim 8, wherein the dielectric resonator has a semicylindrical configuration having a generally rectangular planar base and two opposed generally semicircular planar sides, with one of the semicircular sides abutting the grounded plate and with the rectangular base abutting the conductive wall.

10. An antenna system as claimed in claim 8, wherein the dielectric resonator has a semiconical configuration having a generally triangular planar base and one generally semicircular planar side, with the semicircular side abutting the grounded plate and with the triangular base abutting the conductive wall.

11. An antenna system as claimed in claim 8, wherein the dielectric resonator has a semiconical configuration having a generally triangular planar base and two opposed generally semicircular planar sides, one larger than the other, with one of the semicircular sides abutting the grounded plate and with the triangular base abutting the conductive wall.

12. An antenna system as claimed in claim 8, wherein the dielectric resonator has a trapezoidal cross-section with a generally rectangular planar base and two opposed generally trapezoidal planar sides, with one of the trapezoidal sides abutting the grounded plate and with the rectangular base abutting the conductive wall.

13. An antenna system as claimed in claim 12, wherein the dielectric resonator has a semihexagonal cross-section with a generally rectangular planar base and two opposed generally semihexagonal planar sides, with one of the semihexagonal sides abutting the grounded plate and with the rectangular base abutting the conductive wall.

14. An antenna system as claimed in claim 3 or any claim depending therefrom, wherein the slot is tuned so as to have a resonant frequency of substantially 900MHz and wherein the dielectric resonator is dimensioned to as to have a resonant frequency of substantially 1800MHz.

15. An antenna system as claimed in claim 14, wherein the slot is tuned so as to have a resonant frequency of 950MHz and wherein the dielectric resonator is dimensioned to as to have a resonant frequency of 1830MHz.

16. An antenna system as claimed in any preceding claim, wherein the strip feed is in the form of a microstrip transmission line printed on a side of the dielectric substrate remote from the grounded plane.

17. An antenna system as claimed in claim 5 or any claim depending from claim 5, wherein the conductive wall comprises at least two wall sections arranged with respect to each other at an angle of between 0° and 180°.

18. A mobile telecommunications device incorporating an antenna system as claimed in any preceding claim.

19. A mobile telecommunications device incorporating an antenna system as claimed in claim 7 or any claim depending therefrom, wherein the conductive wall is provided with a dielectric substrate in the form of a printed circuit board bearing other electronic components of the mobile telecommunications device.

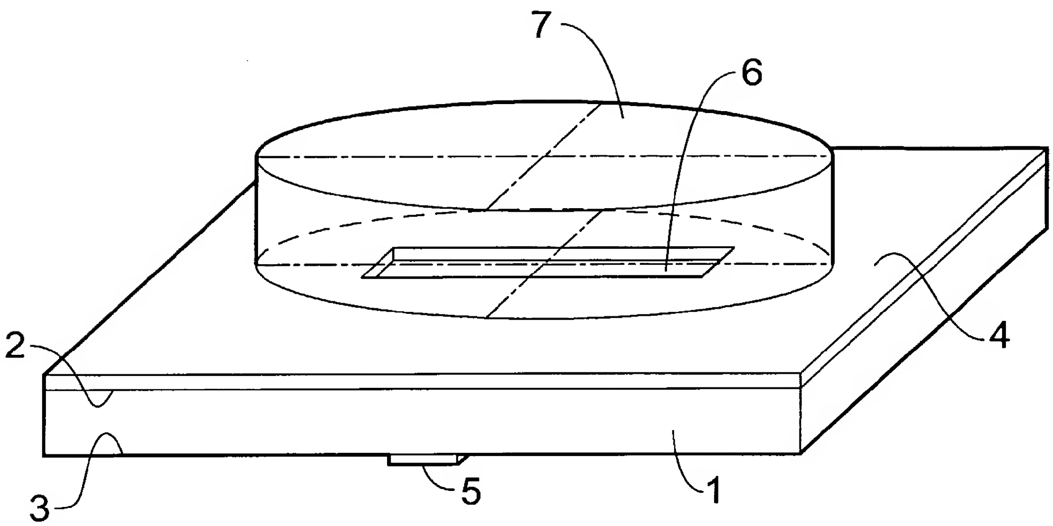


Fig. 1

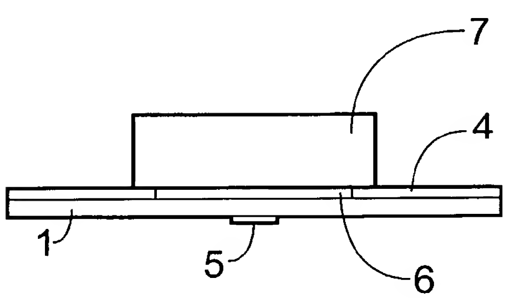


Fig. 2

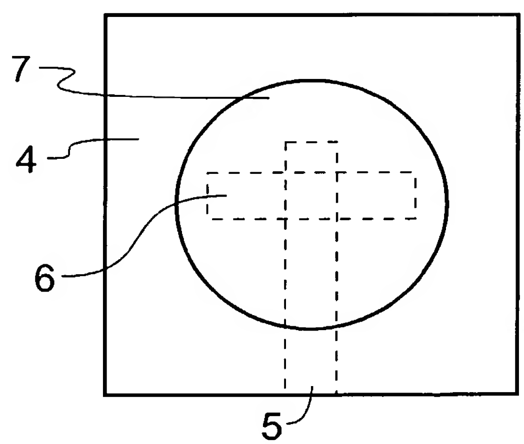


Fig. 3

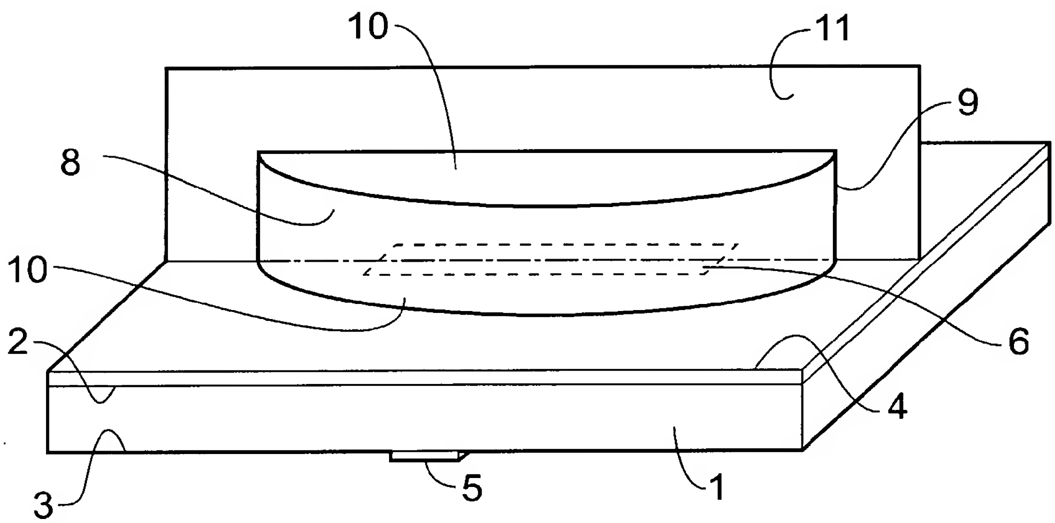


Fig. 4

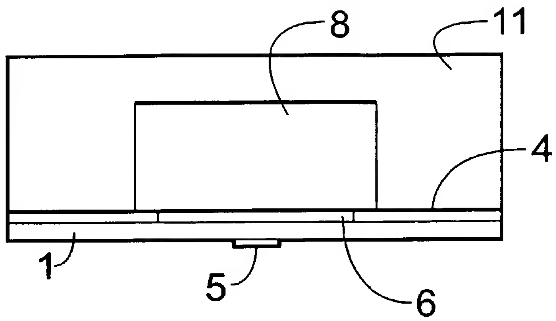


Fig. 5

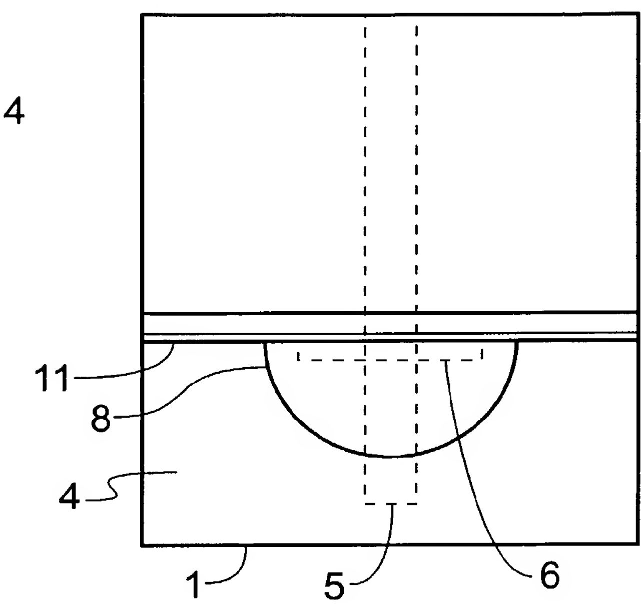


Fig. 6

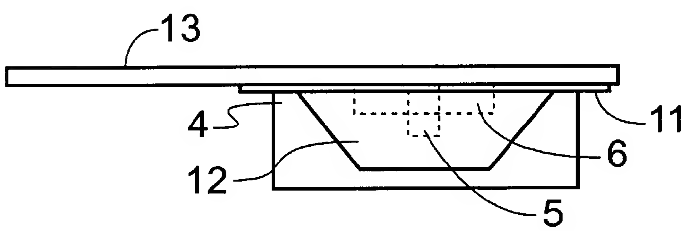


Fig. 7

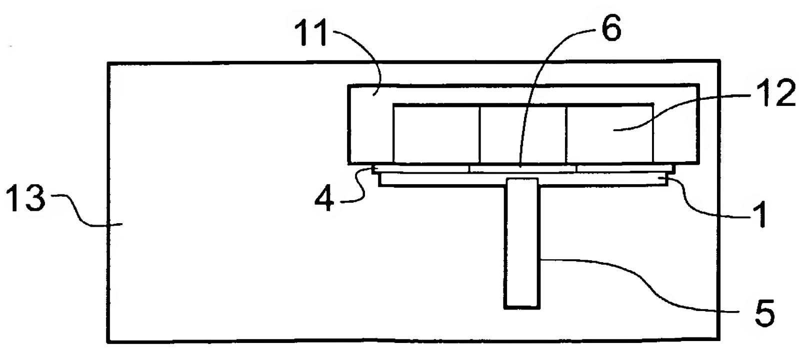
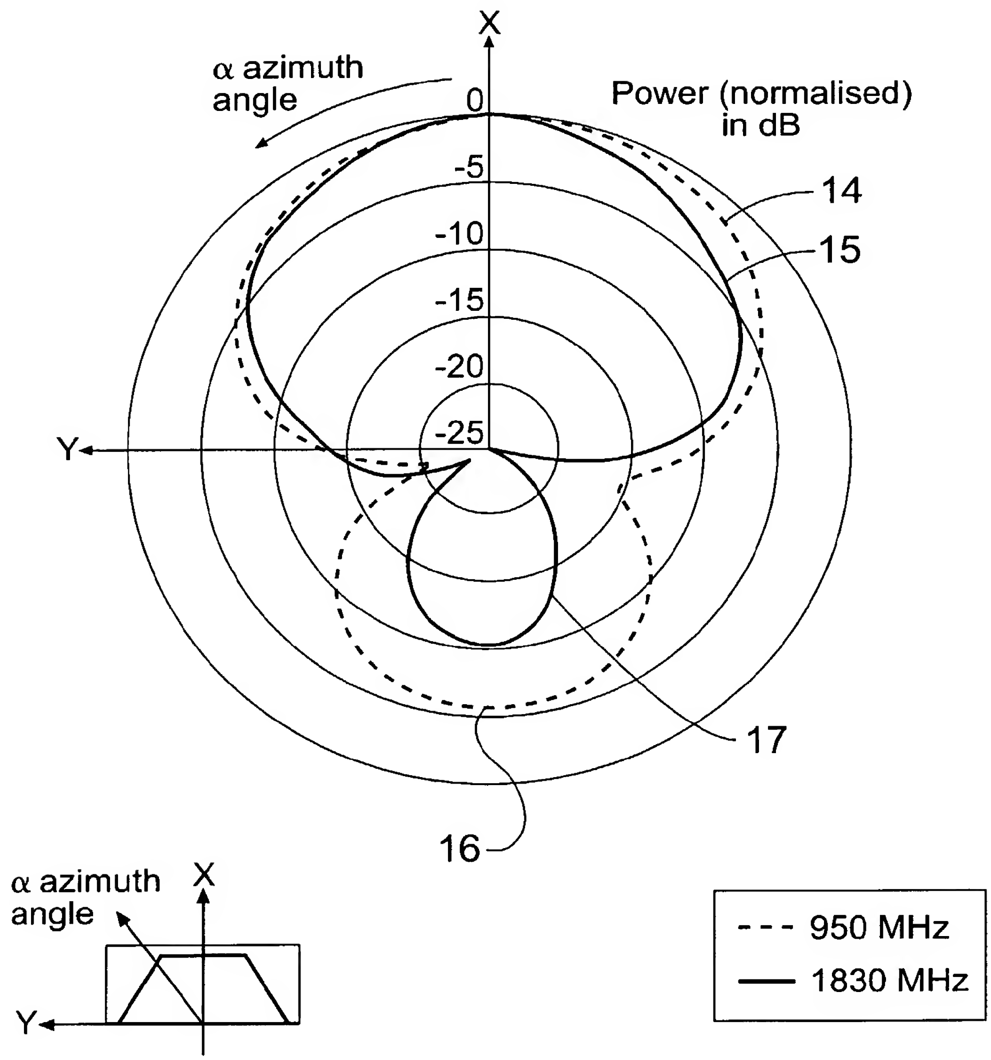


Fig. 8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Power (normalised)
in dB
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15
17
16
α azimuth
angle
X
Y
950 MHz
1830 MHz

Fig. 9

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 02/03065

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01Q9/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, INSPEC, PAJ, IBM-TDB, BIOSIS, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GUO Y-X ET AL: "Characteristics of aperture-coupled cylindrical dielectric resonator antennas on a thick ground plane" IEE PROCEEDINGS: MICROWAVES, ANTENNAS AND PROPAGATION, IEE, STEVENAGE, HERTS, GB, vol. 146, no. 6, 8 December 1999 (1999-12-08), pages 439-442, XP006013596 ISSN: 1350-2417	2-4
Y	page 439, right-hand column, line 35-42	1,5,8, 16-18
	page 440, right-hand column, line 27-32,55-61 page 441, left-hand column, line 8-15; figures 1-8	

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
5 November 2002	12/11/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Cordeiro, J-P

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	TAM M T K ET AL: "Half volume dielectric resonator antenna designs" ELECTRONICS LETTERS, IEE STEVENAGE, GB, vol. 33, no. 23, 6 November 1997 (1997-11-06), pages 1914-1916, XP006008177 ISSN: 0013-5194 page 1914, left-hand column; figure 1 ---	1,5,8, 16-18
A	JUNKER G P ET AL: "Effect of aperture filling on slot-coupled dielectric resonator antennas operating in HEM11mode" ELECTRONICS LETTERS, IEE STEVENAGE, GB, vol. 31, no. 10, 11 May 1995 (1995-05-11), pages 774-775, XP006002806 ISSN: 0013-5194 abstract; figures 1-3 page 774, left-hand column -right-hand column, line 12 ---	4
A	EP 0 801 436 A (COMMUNICATON RESEARCH CENTRE) 15 October 1997 (1997-10-15) column 1, line 16-44; figures 1A,1B -----	2-4

INTERNATIONAL SEARCH REPORT

Inte[...]nal Application No
PCT/GB 02/03065

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			AU	721740	B2	13-07-2000
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